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GB 2134598 A GB 1506956 A GB 0633222 A

(58) Field of search
UK CL (Edition K) F1C CBA CBC CBE CE CFFA CFFH CFNA CFNB
INT CL[5] F04D 5/00 13/12 29/66

(54) Regenerative pump

(57) A multi-stage regenerative pump comprises one or two impellers 5, 5' mounted on a common shaft 2 within a housing 1. Each impeller 5, 5' has at least one annular ring of cells formed on each of the opposite sides thereof, and each ring of cells opens laterally into a respective guide channel 17 in the housing alongside the impeller and cooperates therewith to induce a flow of fluid therethrough between common inlet and outlet ports 14, 15, 16 for both sides. With two impellers 5, 5', flows of both impellers are connected in series with the outlet port (15) of the first impeller (5) being located opposite the outlet port (16) of the second impeller (5') relative to the shaft so that the radial loads generated by the two impellers (5, 5') on the shaft (2) tend to counteract one another. A single impeller with two or more annular rings of cells is described, there being radial loads balancing across the impeller.

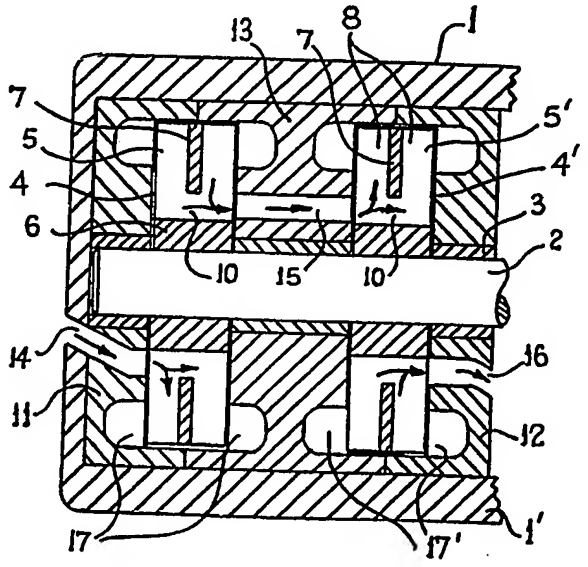

FIG. 1.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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REGENERATIVE PUMP

Technical Field

This invention relates to a regenerative pump of the kind comprising a housing with a pump inlet and a pump outlet, a rotary impeller mounted on a shaft within the housing and having a plurality of blades forming a series of cells spaced angularly around the axis of rotation of the impeller, and a flow channel within the housing extending between the pump inlet and pump outlet and including a guide channel in the housing located alongside the impeller so that the cells open laterally of the plane of rotation of the impeller into said guide channel and co-operate therewith to induce a spiral or helical flow of fluid through the guide channel and cells along the length of said flow channel as the impeller is rotated.

It has been proposed to provide a multi-stage regenerative pump by arranging two or more annular rings of cells with their respective flow channels connected in series so that each in turn acts to increase the head pressure. These rings of cells have been provided on a single impeller either on opposite sides and/or on one side of the impeller. Because of the high head pressures that a

multi-stage pump of this kind can generate, high radial loads are exerted by the impeller on the shaft. In one arrangement, it has been proposed to balance these high radial loads by providing an impeller with the same arrangement of multiple annular rings of cells on both sides of the impeller and with the pump inlets and outlets on opposite sides offset relative to one another in the direction of rotation. Each side of the impeller and the respective adjacent housing therefore forms a multi-stage pump with the flow channels on each side connected in series between an inlet and an outlet and with the inlets of both sides connected together and the outlets of both sides connected together so that the two sides of the pump are connected in parallel.

Preferably, the pump inlets and pump outlets on both sides of the impeller are angularly offset by 180° relative to one another so that the radial forces on both sides are fully balanced.

Disclosure of the Invention

An object of the present invention is to provide an improved regenerative pump in which radial loads generated by the impellers tend to

counteract one another.

According to one aspect of the present invention, a multi-stage regenerative pump comprises two impellers mounted on a common shaft within a housing, each impeller having two annular rings of cells formed on the opposite sides thereof that each open laterally into a respective guide channel in the housing alongside the impeller and cooperate therewith to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, characterised in that the flow of fluid on opposite sides of each impeller are connected between common inlet and outlet ports, and that the flows of both impellers are connected in series with the outlet port of a first impeller being connected to the inlet port of the second impeller with the outlet port of the first impeller being located opposite the outlet port of the second impeller relative to the shaft so that the radial loads generated by the two impellers on the shaft tend to counteract one another.

Preferably, the flows on opposite sides of each

impeller are connected in parallel so that the pressures on both sides are balanced axially.

Axial stacking of the impellers is readily accommodated in a compact form with a multi-part axially-stacked housing assembly in which preferably an intermediate part of the housing between two impellers has recesses formed on opposite sides thereof to receive the impellers. The axial spacing between impellers can be kept to a minimum in this manner for compactness and also to reduce the resultant couple produced by out of balance forces between the two impellers.

Preferably, the connection between the outlet port of the first impeller and the inlet port of the second impeller is formed in the body of the housing between the two impellers. This is readily accommodated if the respective outlet and inlet ports open laterally at the sides of the impellers, this porting arrangement being possible if the cells on both sides of each impeller are directly interconnected, for example, by axial openings through the body of the impeller.

According to another aspect of the present

invention, a multi-stage regenerative pump comprises a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having two or more annular rings of cells, each ring lying on a different radius of the impeller and comprising a plurality of cells spaced angularly around the axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, the inlet and outlet ports of the guide channels being interconnected so that the guide channels are connected in series between the pump inlet and pump outlet, characterised in that said guide channels form a first set of guide channels and in that a second set of guide channels is provided in the housing between the respective inlet and outlet ports which are interconnected so that the second set of guide channels are connected in series between the pump inlet and pump outlet, a guide channel of each set of guide channels cooperating with a corresponding ring of cells but these guide channels and their inlet and outlet ports being offset angularly so

that the radial loads generated by the pressures therein tend to counteract one another.

The rings of cells on the impeller therefore cooperate with each set of guide channels to produce a corresponding multi-stage pumping action which progressively increases the head pressure around the housing within each set of guide channels, but angular offsetting of these two sets of guide channels relative to one another brings these pressure patterns into radial opposition with one another so that they counteract one another in their affect on the radial loading of the shaft. In this way, it is possible to balance the radial loads fully, although it may be preferred to retain some predetermined radial loading to suit the bearings on which the impeller is mounted on the shaft.

According to another aspect of the invention, a multi-stage regenerative pump comprises a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having two or more annular rings of cells, each ring lying of a different radius of the impeller and comprising a plurality of cells spaced angularly around the

axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, the inlet and outlet ports of the guide channels being interconnected so that the guide channels are connected in series between the pump inlet and pump outlet, characterised in that the inlet and outlet ports of the guide channels are arranged angularly relative to one another so that the radial loads generated by the pressures therein tend to counteract one another.

According to another aspect of the invention, a regenerative pump comprises a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having an annular ring of cells spaced angularly around the axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, characterised in that the

inlet and outlet ports of the guide channels are arranged angularly relative to one another so that the radial loads generated by the pressures therein tend to counteract one another.

Description of the Drawings

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is an axial section through a multi-impeller, multi-stage regenerative pump according to a first embodiment of the invention,

Figure 2 is an axial end view of the pump of Figure 1,

Figure 3 is an edge on view of part of an impeller of the pump of Figure 1,

Figure 4 is an axial section through a multi-impeller, multi-stage regenerative pump according to a second embodiment of the invention,

Figure 5 is an axial end view of the pump of Figure 4,

Figure 6 is a schematic side view of a single-impeller, multi-stage regenerative pump according to the invention with fluid pressure curves,

Figure 7 is a section along a diametral plane of the pump in Figure 6,

Figure 8 is a schematic side view similar to that of Figure 6 but showing the inlet and outlet fluid supplies to the impeller,

Figure 9 is a schematic side view of another single impeller, multi-stage regenerative pump according to the invention, and

Figure 10 is a schematic side view of a single impeller regenerative pump according to the invention.

Mode of Carrying Out the Invention

The regenerative pump illustrated in Figures 1 to 3 comprises a housing 1 that rotatably supports a shaft 2 in bearings 3 and defines a pair of cylindrical chambers 4, 4' that each receives one of a pair of impellers 5, 5' mounted on the shaft

2. Each impeller 5 comprises a hub 6 and a ring 7 that extends radially outwards from the hub 6 and carries a set of blades 8 on both sides that extend laterally and radially of the ring 7. The blades 8 are formed integrally with the hub 6 and ring 7 and conform to a cylindrical profile at their outer periphery to be received as a close fit within the chamber 4, 4'.

The blades 8 on each side of the ring 7 extend away from the ring in the direction of rotation R of the impeller at an angle of approximately 45 degrees to the central plane of rotation Z-Z of the ring as shown in Figure 3. The spaces 9 between the blades 8 define a ring of cells each side of the impeller. These cells are connected by a set of holes 10 formed through the ring 7 at the root of the blades 8.

The housing 1 is formed in three sections comprising two outer sections 11, 12 and an intermediate section 13 which are stacked together axially within an outer sleeve 1' with their cooperating faces substantially coincident with the central planes of rotation of the impellers 5, 5'. A pump inlet 14 is formed in the side wall of

one outer section 11 and opens into the chamber 4 adjacent to the inner ends of the cells 9. A transfer port 15 is formed through the side wall of the intermediate section 13 of the housing and connects the two chambers 4, 4' at points adjacent to the inner ends of the cells 9 but in a location which is offset angularly in the direction of rotation R of the impeller by approximately 225 degrees from the pump inlet 14, as shown in Figure 2. A pump outlet 16 is formed in the side wall of the other outer section 12 and opens into the chamber 4' adjacent to the inner ends of the cells 9 but in a location which is offset angularly in the direction of rotation R of the impeller by approximately 225 degrees from the transfer port 15, as shown in Figure 2.

A respective pair of guide channels 17, 17' is formed in the cooperating side walls of the section 11, 12, 13 of the housing so as to open into the chamber 4, 4' therebetween. The one pair of guide channels 17 extend alongside the outer portion of the impeller 5 over an angle of approximately 315 degrees between the pump inlet 14 and the transfer port 15. The other pair of guide channels 17' extend alongside the outer

portion of the impeller 5' over an angle of approximately 315 degrees between the transfer port 15 and the pump outlet 16. The uninterrupted portion 18 of the side wall between the closed ends of each guide channel 17, 17' acts as a stripper which limits the direct flow of fluid from the transfer port 15 to the pump inlet 14 and from the pump outlet 16 to the transfer port 15.

In operation, the impellers 5, 5' rotate in the direction R and serve to produce a radially outward flow of fluid in the cells 9 through centrifugal action. At the outer periphery of each impeller, the fluid is directed laterally outwards into the guide channels 17, 17' where it is recirculated inwards back into the cells 9. This recirculating action continues along the whole length of each pair of guide channels 17, 17' as the impeller rotates, thereby increasing the pressure of the fluid in two stages, first by the action of the first impeller 5 and then by the action of the second impeller 5' which is connected in series with the first impeller via the transfer port 15.

The manner in which the pressure increases in each

successive stage of the pump is illustrated in Figure 2, P1 showing the increasing magnitude of the radial pressure over the 225 degrees circumference of the guide channels 17 of the first impeller 5 between the pump inlet 14 and the transfer port 15, and P2 showing the increasing magnitude of the radial pressure over the 225 degrees circumference of the guide channels 17' of the second impeller 5' between the transfer port 15 and the pump outlet 16. Because these pressure distributions P1 and P2 are diametrically opposed, they tend to balance one another producing a lower net pressure distribution on the shaft. That is, the peak pressure at the end of the first stage at transfer port 15 is on the opposite side of the shaft 2 to the peak pressure at the end of the second stage at the pump outlet 16, and corresponding intermediate pressures in the two stages are also similarly opposed. As shown in Figure 2, the pump outlet 16 lies on the opposite side of a diametral plane perpendicular to the radial plane through the centre of the transfer port 15.

A second embodiment of the invention is illustrated in Figures 4 and 5 which like the

regenerative pump of Figures 1 to 3 comprises a pair of impellers 5, 5' mounted on a shaft 2 within cylindrical chambers 4, 4' defined by a multi-part axially stacked housing 1. Each impeller 5, 5' is similar in form to those of the first embodiment except that the holes 10 are omitted so that the two rings of cells 9 on opposite sides of each impeller are separate from one another. Each ring of cells 9 therefore has its own associated inlet and outlet ports 19, 20; 19', 20' connected by a guide channel 17, 17' in the side wall of the adjacent housing section. Further, the two inlet ports 19, 19' associated with each impeller 5, 5' are located directly opposite one another on either side of the impeller and are each connected to a respective inlet manifold 21, 21'in the outer sleeve 1', and the two outlet ports 20, 20' associated with each impeller 5, 5' are located directly opposite one another on either side of the impeller and are each connected to a respective outlet manifold 22, 22' in the outer sleeve 1' (Figure 5). The outlet manifold 22 of the first impeller 5 is connected via a transfer connection 23 to the inlet manifold 21' of the second impeller 5'so that the two impellers 5, 5' are connected in series between

the inlet manifold 21 of the first impeller 5 and the outlet manifold 22' of the second impeller 5'.

The relative angular arrangement of the inlet and outlet ports 19, 20; 19', 20' and the guide channels 17, 17' is shown in Figure 5, the guide channels 17, 17' each extending in an arc over an angle of approximately 270 degrees between the inlet and outlet ports 19, 20; 19', 20', but the respective inlet ports 19, 19' being offset by an angle of approximately 180 degrees relative to one another. In this manner, the circumferential pressure patterns P1, P2 of the two impellers 5, 5' are made to balance one another producing a lower net pressure distribution, as shown in Figure 5.

A third embodiment of the invention is illustrated in Figures 6 and 7 comprising an impeller 25 mounted on a shaft 26 in a cylindrical chamber 27 within a housing 28. Each side of the impeller is similarly formed with three concentric rings of cells 29, the rings being separated by two annular walls 30 and the individual cells being separated from one another by radially extending walls 31. Each ring of cells has associated with it a pair

of arcuate guide channels 32 which are formed in the adjacent side wall of the housing 28 so as to open into the cells 9. Each guide channel 32 extends circumferentially in the direction of rotation R of the impeller between an inlet port 33 at one end and an outlet port 34 at the other end, and each pair of guide channels 32 lies on a circle centred on the shaft 26 with their respective inlet ports 33 and outlet ports 34 arranged diametrically opposite one another. Further, the outlet ports 34 of the innermost guide channels 32 are each located on a common diameter with the inlet ports 33 of the centre guide channels, and respective adjacent pairs of these outlet ports 34 and inlet ports 33 are connected together by an inner transfer duct 35 in the housing so that fluid can flow from each innermost guide channel 32 to a respective centre guide channel. Similarly, the outlet ports 34 of the centre guide channels 32 are each located on a common diameter with the inlet ports 33 of the outermost guide channels, and respective adjacent pairs of these outlet ports 34 and inlet ports 33 are connected together by an outer transfer duct 36 in the housing so that fluid can flow from each centre guide channel 32 to a respective outermost

guide channel.

Thus, the three pairs of guide channels 32 are connected together via the inner and outer transfer ducts 35, 36 as two sets of three guide channels connected in series and each on successively larger radii from the centre of the shaft to conduct fluid from an innermost inlet port 33 to an outermost outlet port 34 in three stages. Each guide channel extends over an arc of approximately 130 degrees so that each set of three guide channels 32 covers in excess of one complete turn around the shaft 26.

As shown in Figures 7 and 8, the two innermost inlet ports 33 on each side of the impeller 25 are connected via channels 37 within the housing 28 to a common pump inlet 38, and the two outermost outlet ports 34 on each side of the impeller 25 are connected via channels 39 within the housing 28 to a common pump outlet 40.

The manner in which the head pressure increases progressively within successive guide channels of each set, is illustrated by the outer pressure curves in Figure 6. From this, it will be clear

that the pressures of each set tend to counterbalance one another in their loading affect on the central shaft 26. The same pressure balancing affect is produced on both sides of the impeller 25. Thus a perfectly balanced impeller can be obtained, although in practice it may be desired to provide a predetermined asymmetry in the arrangement of inlet and outlet ports 33, 34 so as to produce a net loading force of the impeller on shaft 26 to enhance smooth running of the impeller.

A fourth embodiment of the invention is illustrated in Figure 9 which is similar to that of Figures 7 and 8 except that only one set of guide channels 32 is provided in the housing on each side of the impeller, however, the relative angular orientation of the three guide channels 32 of each set is such that the radial loads generated by the pressures therein tend to counteract one another. The outlet and inlet ports 34, 33 of respective guide channels 32 that are connected together are angularly offset to provide the desired balancing of radial loads on the shaft, these ports 34, 33 being interconnected via extended transfer ducts 35, 36 in the housing.

The lengths of the guide channels 32 are also selected to provide the desired degree of balancing of radial loads.

A fifth embodiment of the invention is illustrated in Figure 10 which comprises a single impeller similar to impeller 5 in Figures 1 and 2 but with a housing 1 having a pair of guide channels 41 on each side of the impeller, each in cooperation with the cells 9 formed between the blades 8 of the impeller so as to conduct fluid flow between respective inlet and outlet ports 42, 43 which are connected via channels 44, 45 in the housing to a pump inlet 46 and a pump outlet 47. The two guide channels 41 and their respective inlet and outlet ports 42, 43 are arranged diametrically opposite one another relative to the shaft of the impeller so that the radial loads generated by the pressures therein tend to counteract one another.

CLAIMS

1. A multi-stage regenerative pump comprising two impellers mounted on a common shaft within a housing, each impeller having two annular rings of cells formed on the opposite sides thereof that each open laterally into a respective guide channel in the housing alongside the impeller and cooperate therewith to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, characterised in that the flow of fluid on opposite sides of each impeller are connected between common inlet and outlet ports, and that the flows of both impellers are connected in series with the outlet port of a first impeller being connected to the inlet port of the second impeller with the outlet port of the first impeller being located opposite the outlet port of the second impeller relative to the shaft so that the radial loads generated by the two impellers on the shaft tend to counteract one another.

2. A pump as claimed in claim 1 in which the inlet port of the first impeller is located opposite the inlet port of the second impeller

relative to the shaft.

3. A pump as claimed in claim 1 in which the flows between the inlet and outlet ports on the opposite sides of both impellers extend angularly around the shaft to substantially the same extent.

4. A pump as claimed in claim 3 in which the flows between the inlet and outlet ports extend substantially 180 degrees around the shaft.

5. A pump as claimed in claim 3 in which the flows between the inlet and outlet ports extend in excess of 180 degrees around the shaft.

6. A pump as claimed in any one of the preceding claims in which the housing comprises a multi-part axially-stacked assembly in which an intermediate part of the housing between the two impellers has recesses formed on opposite sides thereof to receive the impellers.

7. A pump as claimed in claim 6 in which the connection between the outlet port of the first impeller and the inlet port of the second impeller is formed in the intermediate part of the housing

between the two impellers.

8. A pump as claimed in claim 7 in which the cells on both sides of each impeller are directly interconnected by axial openings through the body of the impeller, and the inlet and outlet ports open axially of the intermediate part at the sides of the impellers.

9. A pump as claimed in any of claims 1 to 6 in which the connection between the outlet port of the first impeller and the inlet port of the second impeller is formed by a connection externally of the housing.

10. A pump as claimed in any one of the preceding claims in which the flows on opposite sides of each impeller are connected in parallel so that the pressures on both sides are balanced axially.

11. A multi-stage regenerative pump comprising a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having two or more annular rings of cells, each ring lying on a different radius of the impeller and comprising a plurality of cells spaced

angularly around the axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, the inlet and outlet ports of the guide channels being interconnected so that the guide channels are connected in series between the pump inlet and pump outlet, characterised in that said guide channels form a first set of guide channels and in that a second set of guide channels is provided in the housing between respective inlet and outlet ports which are interconnected so that the second set of guide channels are connected in series between the pump inlet and pump outlet, a guide channel of each set of guide channels cooperating with a corresponding ring of cells but these guide channels and their inlet and outlet ports being offset angularly so that the radial loads generated by the pressures therein tend to counteract one another.

12. A pump as claimed in claim 11 in which the guide channels of the first and second set cooperating with a ring of cells have

corresponding outlet ports arranged opposite one another.

13. A pump as claimed in claim 11 or 12 in which the guide channels of the first and second set cooperating with a ring of cells have corresponding inlet ports arranged opposite one another.

14. A pump as claimed in any one of claims 11 to 13 in which the guide channels of the first and second set cooperating with a ring of cells extend circumferentially around the shaft to substantially the same extent as one another.

15. A pump as claimed in any one of claims 11 to 14 in which the guide channels of both sets have substantially the same circumferential length.

16. A pump as claimed in any one of the preceding claims in which the guide channels of each set are interconnected so that successive guide channels through which fluid flows are located on successively greater radii.

17. A pump as claimed in any one of claims 11 to

16 in which each set of guide channels comprises three guide channels.

18. A pump as claimed in any one of claims 11 to 17 in which similar first and second sets of guide channels are provided on each side of the impeller in the housing alongside the impeller, each first and second set of guide channels on either side of the impeller being interconnected in series between the pump inlet and pump outlet.

19. A multi-stage regenerative pump comprising a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having two or more annular rings of cells, each ring lying on a different radius of the impeller and comprising a plurality of cells spaced angularly around the axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between and inlet port and an outlet port, the inlet and outlet ports of the guide channels being interconnected so that the guide channels are connected in series between the

pump inlet and pump outlet, characterised in that the inlet and outlet ports of the guide channels are arranged angularly relative to one another so that the radial loads generated by the pressures therein tend to counteract one another.

20. A pump as claimed in claim 19 in which at least one outlet port is located opposite another outlet port relative to the shaft.

21. A pump as claimed in claim 19 or 20 in which respective inlet and outlet ports of guide channels that are connected together are angularly offset relative to one another about the shaft.

22. A regenerative pump comprising a housing with a pump inlet and a pump outlet, an impeller rotatably mounted within the housing having an annular ring of cells spaced angularly around the axis of the impeller and opening laterally into a respective guide channel in the housing alongside the impeller so as to induce a spiral or helical flow of fluid through the guide channel and cells along the length of the guide channel between an inlet port and an outlet port, characterised in that the inlet and outlet ports of the guide

channels are arranged angularly relative to one another so that the radial loads generated by the pressures therein tend to counteract one another.

23. A pump as claimed in claim 22 in which at least one outlet port is located opposite another outlet port relative to the shaft.

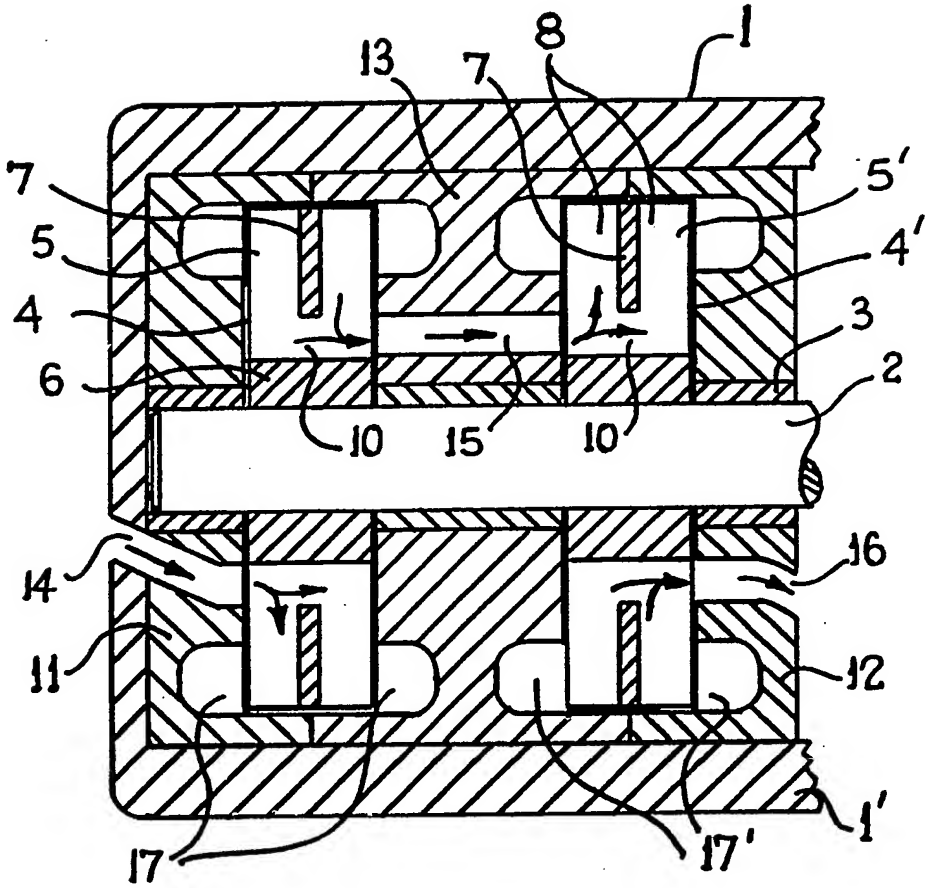

Fig. 1.

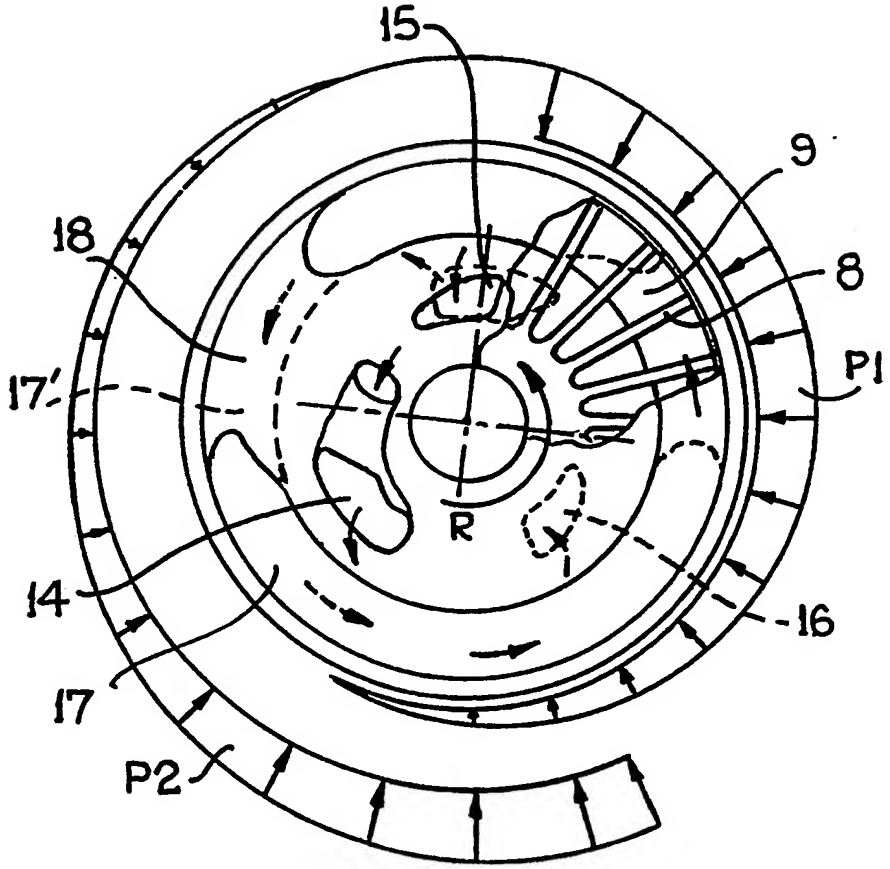

FIG.2.

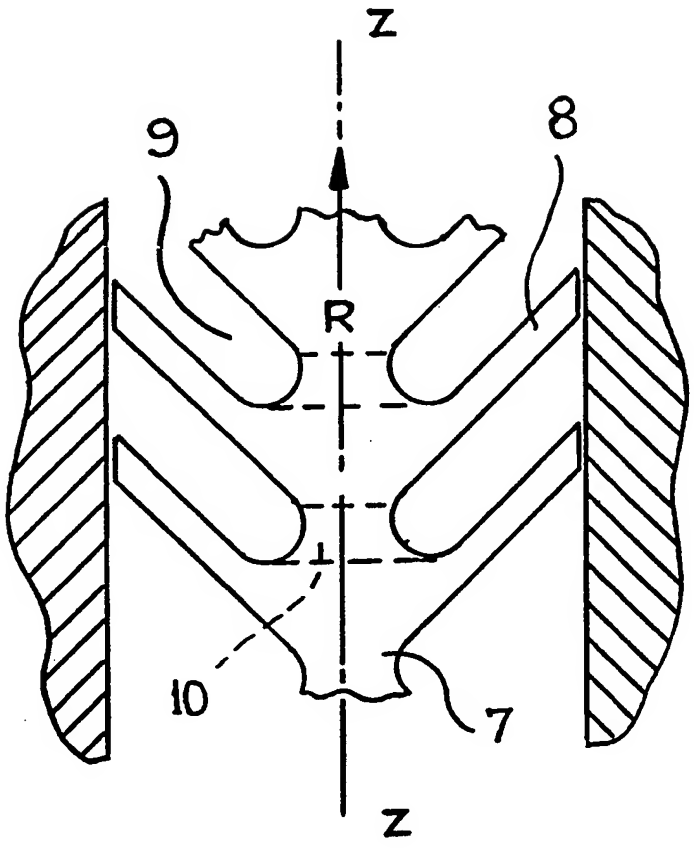

FIG. 3.

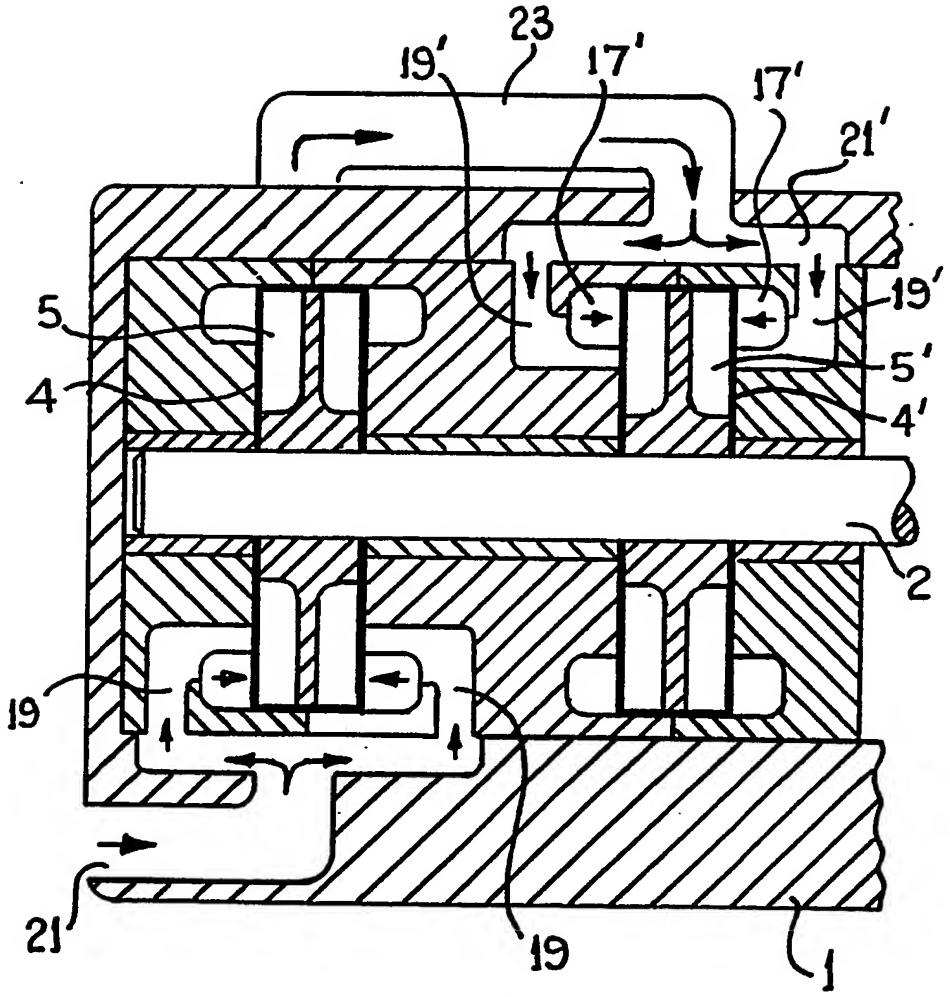

FIG. 4.

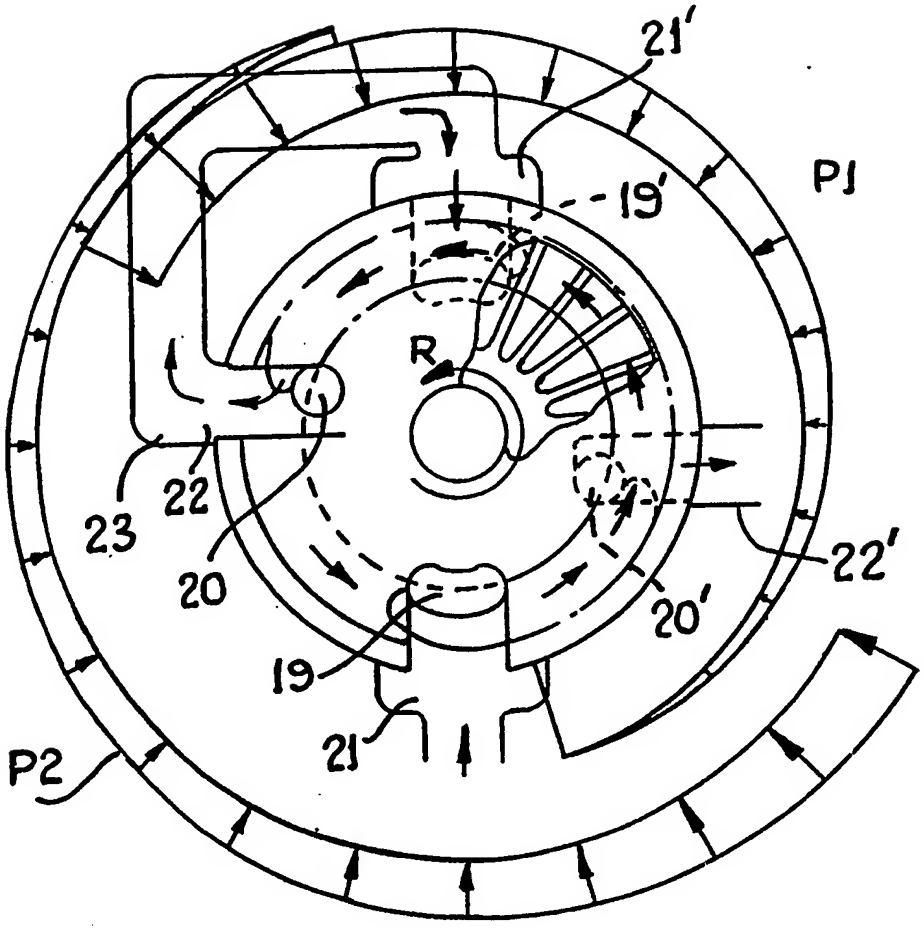

FIG. 5.

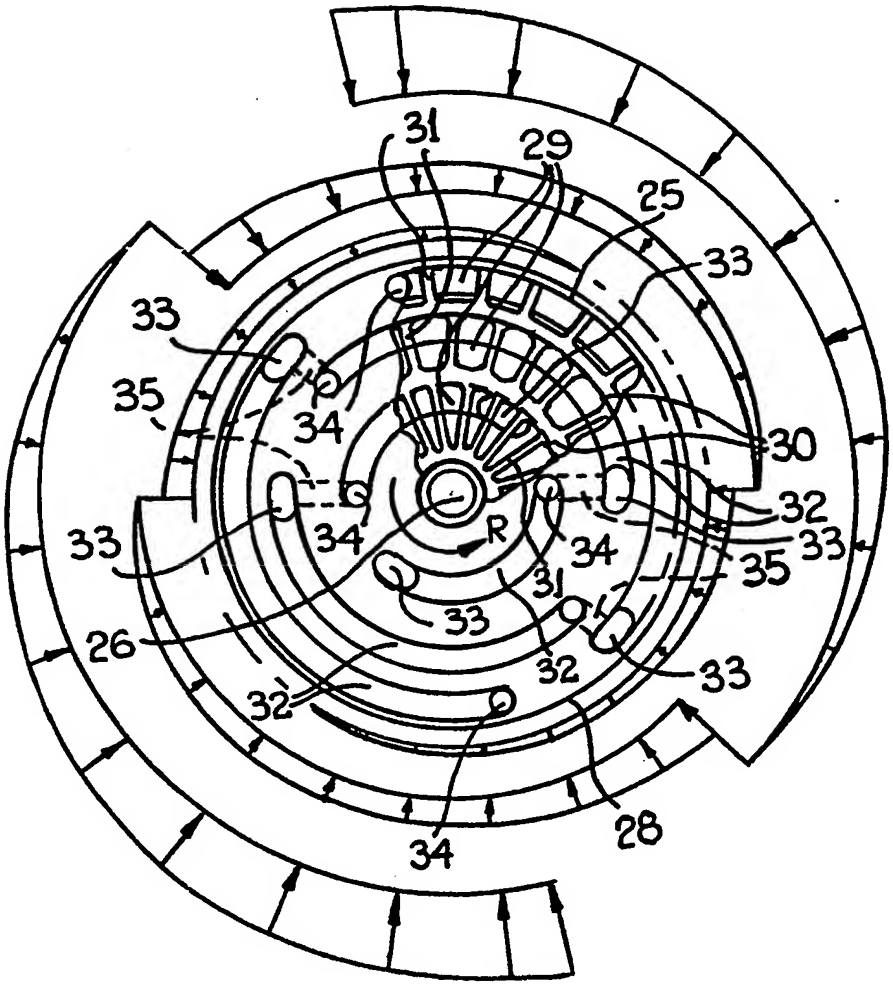

FIG.6.

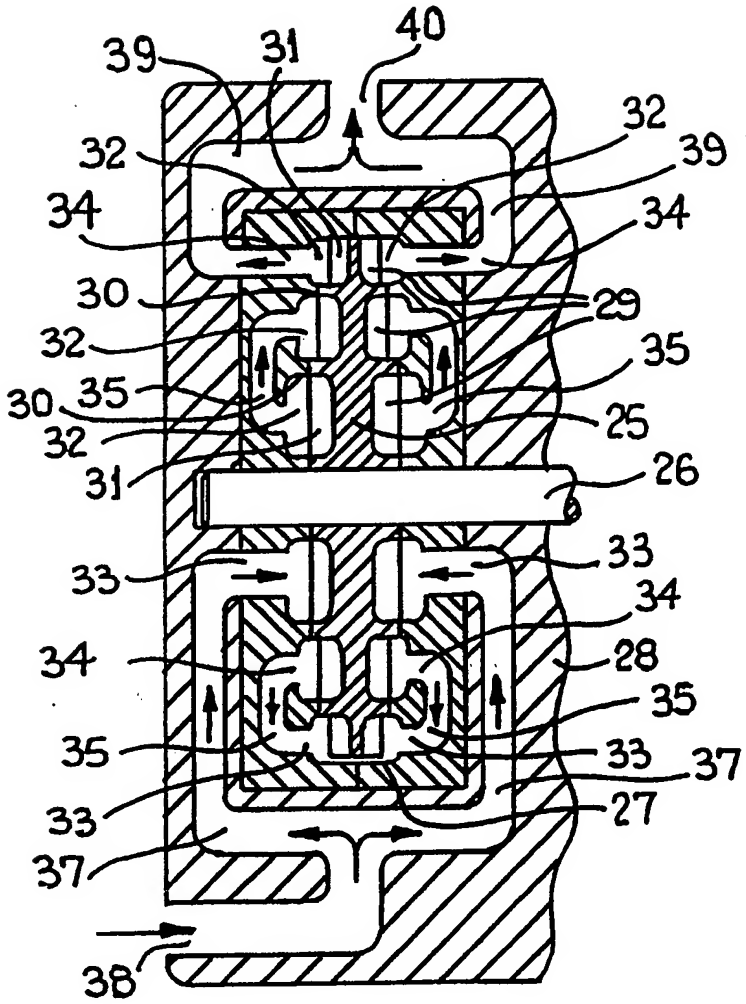
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FIG. 7.

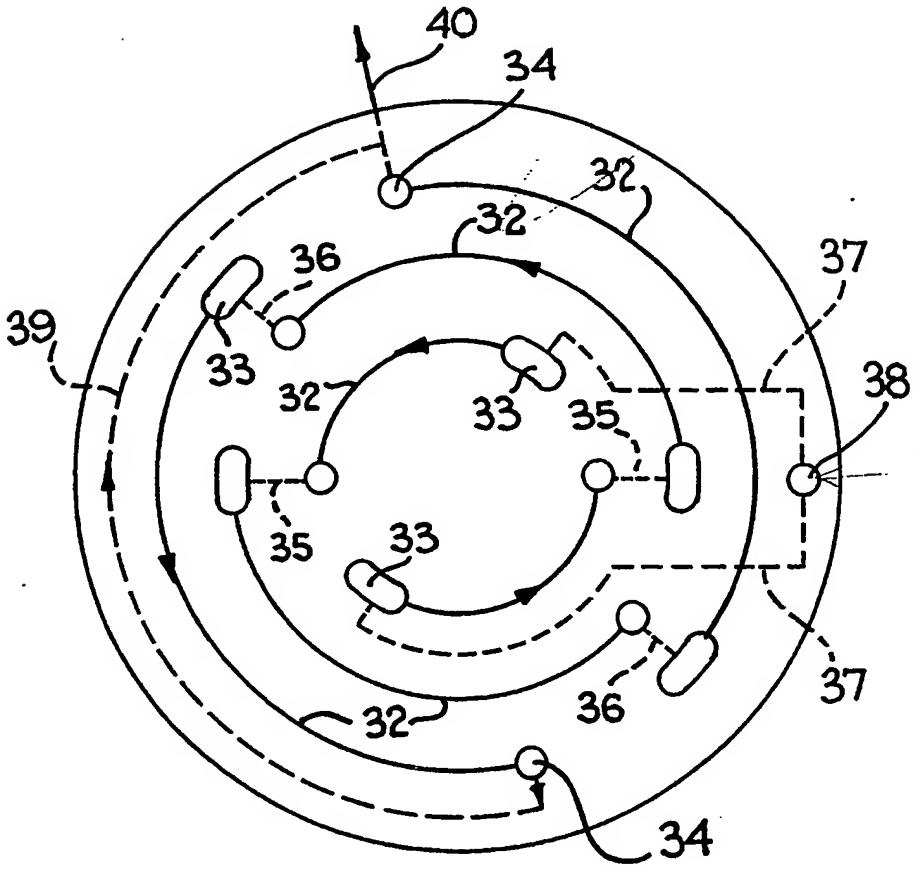

FIG. 8.

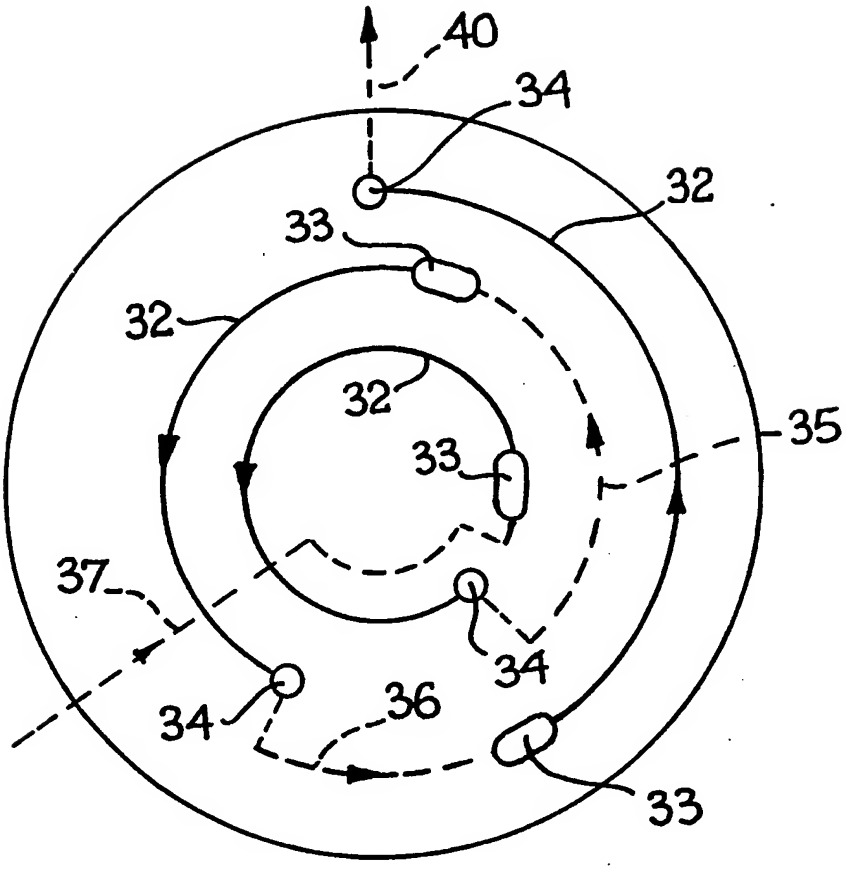

FIG. 9.

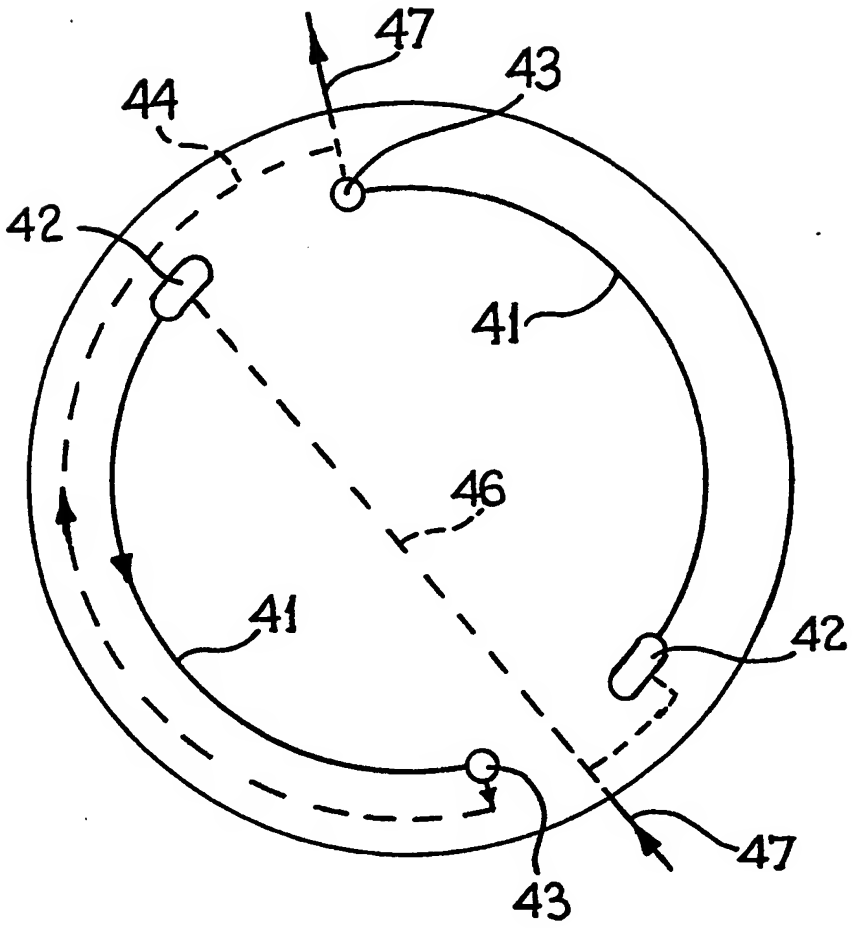

FIG. 10.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9126655.1

Relevant Technical fields

(i) UK Cl (Edition K) F1C(CBA,CBC,CBE,CE,CFNA,CFNB, CFFA,CFFH)

(ii) Int CL (Edition 5) F04D 5/00; 13/12; 29/66

Search Examiner
M D WALKER

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
13 MAY 1992

Documents considered relevant following a search in respect of claims 1-10

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2134598 A	(BOSCH) page 2, lines 83-98	8
X	GB 1506956	(ROTH) page 2, lines 109 to page 3, line 15; page 3, line 92 to page 4 line 6; page 5, lines 113 to 127	1-7 at least
Y	GB 1506956	(ROTH)	8
X	GB 633222	(LINDE AIR) page 2, line 93 etc	1,9 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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